

GEORGIA INSTITUTE OF TECHNOLOGY  
School of Aerospace Engineering  
Aerospace Systems Design Laboratory

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## Year 1 Interim Report

# NASA Multidisciplinary Design and Analysis Fellowship Program

### *Year 1: Interim Results*

*January 1995 - September 1995*

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MULTIDISCIPLINARY DESIGN AND  
ANALYSIS FELLOWSHIP PROGRAM Interim  
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Multidisciplinary Design and Analysis Program  
Critical Technologies Division, Code RR  
NASA Headquarters  
300 E Street, SW  
Washington, DC 20546

November 1995

## **Year 1 Interim Report**

### **Summary**

This report is a Year 1 interim report of progress on the NASA Multidisciplinary Design and Analysis Fellowship Program covering the period, 1 January 1995 through 30 September 1995. It summarizes progress in establishing the MDA Fellowship Program at Georgia Tech during the initial year. Progress in the advertisement of the program, recruiting results for the 1995-96 academic year, placement of Fellows in industry during Summer 1995, program development at the M.S. and Ph.D. levels, and collaboration and dissemination of results are summarized in this report. Further details of the first year progress will be included in the report from the Year 1 Workshop to be held at NASA Langley on December 7-8, 1995.

### **Introduction**

#### ***Aerospace Systems Design Lab***

The Aerospace Systems Design Laboratory (ASDL) is a laboratory organized within the School of Aerospace Engineering at Georgia Tech. It is a confederation of faculty members in the School along with their graduate students that together are dedicated to education and research in the areas of aerospace systems design and systems integration. The ASDL was formed by Professors Dan Schrage and Jim Craig who are the nominal co-directors while Professor Dimitri Mavris is an Associate Director and Lab Manager. Professor John Olds who has just joined the faculty this academic year is a member of the Lab and will be developing and directing the efforts in space systems design. Professor Michael Jenkins who is responsible for the undergraduate capstone design program is also a member of the Lab but is not directly involved in the research activities.

Research emphasis in ASDL currently focuses in the first two areas:

- Expand the understanding, development and integration of comprehensive aerospace design and analysis computational tools across the aerospace spectrum, and
- Create a computer integrated IPPD environment for the intelligent generation, evaluation and navigation of aerospace system design.

The ASDL is currently organized in a loose fashion around three principal areas of application and current research with the faculty members sharing responsibilities for student supervision. These are: aircraft systems, rotorcraft systems and spacecraft systems, and the relationships and participating students are shown in Figure 1. ASDL currently is funded by sponsors from NASA, the DoD and industry.

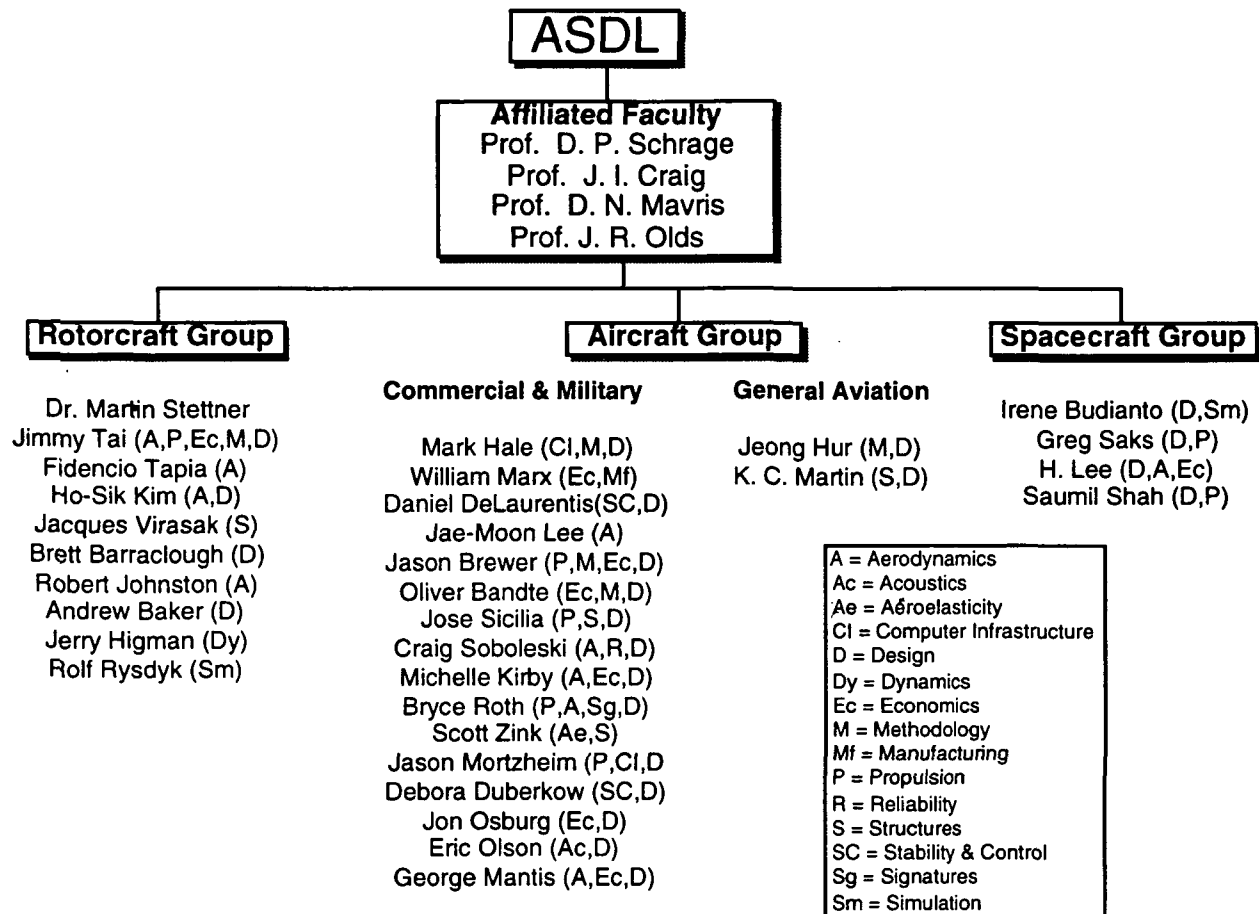


Figure 1. ASDL Organization and Graduate Student Assistants

The ASDL has contributed to the MDA field of research in a number of areas during the past year. An Integrated Product and Process Development (IPPD) methodology continues to be developed, and recent results were reported in several M.S. and Ph.D. dissertations. The methodology is being used in our two-quarter graduate aerospace design courses. The IPPD methodology emphasizes product decomposition and process recomposition activities that occur concurrently throughout the design of complex systems. Using this methodology, ASDL research is being conducted in the following MDA-related areas: hierarchic and non-hierarchic decomposition procedures, process-based recomposition strategies, sensitivity determination, uncertainty analysis and propagation in design, design of experiments methodologies for design, response surface methodologies, design process description from a decision-based perspective, and engineering systems information modeling. In addition, the computer tools necessary to support these activities are being developed, including agent-based architectures, wrapping strategies (for open and proprietary resources), and process control techniques for coupled analysis. Our principal sponsored research application areas (with sponsor) include: single/twin engine assessment study (JAST), Civil Tiltrotor aero-servoelastic optimization (NASA), new developments in IPPD (NASA), wing multi-level structural optimization (NASA), and product-process based economic analysis of the HSCT (NASA).

### NASA MDA Fellowships

The NASA Multidisciplinary Design and Analysis Fellowship Program at Georgia Tech was initiated in February 1995 in the first year of what is planned to be a 3 year program. The Program builds on the initial successes at Georgia Tech with our newly created graduate aerospace systems

design program. It extends and enhances the current graduate courses in aerospace systems design including the analytically oriented courses and particularly the team-oriented systems design and integration projects. It seeks continuous improvement through the incorporation of research results directly into course content, and it provides technology exchange with our industry partners.

The technology exchange involves NASA Fellows conducting research while serving on highly focused multidisciplinary project teams in industry that are addressing HSCT and Dual-Use VTOL aircraft initiatives. The intern-type assignments with our industry partners follow the students' formal introduction to IPPD methods and tools as part of our MDA curriculum. This approach provides the three essential elements for successful technology transfer: personnel exchange, a focused project, and teamwork experience.

The Program is using the latest developments in educational technology and communications to allow collaborative teamwork and to electronically publish the curriculum and research results. In Years 2 and 3 the Program will address the needs of the practicing engineer through continuing education.

At the present time, six NASA MDA Fellowships have been awarded for the 1995-96 academic year to outstanding candidates selected from a large field of applicants. The Fellows are pursuing their graduate studies and conducting the associated research in the Aerospace Systems Design Laboratory in the School of Aerospace Engineering at Georgia Tech.

## Recruiting for Academic Year 1995-96

Recruiting for the current 1995-96 academic year got off to a late start due to the delay in funding until early February 1995. Nonetheless, a sizable pool of graduate school applicants in Aerospace Engineering along with several current graduate students provided the initial population of candidates. Recruiting efforts were concentrated on current channels within the academic community and on the Georgia Tech campus. Advertisements such as those shown in Appendix A were used in mailings and in on-campus advertising. Particular attention was directed to the graduating seniors in the undergraduate programs in both Aerospace Engineering and in Mechanical Engineering.

NASA MDA Fellowships carrying a significantly enhanced stipend (\$15,000 per year for a one third time fellowship compared to \$12,000 per year for a standard one third time assistantship) were offered to a carefully selected group of 7 applicants selected from the M.S. applicants for Fall 1995. Two students currently in the M.S. program were also offered Fellowships.

Due to the late availability of funding, two of the applicants turned down the offers, but the remaining 6 applicants accepted NASA MDA Fellowships for the 1995-96 academic year. The names of each along with program status, areas of interest, and advisor are given in the table below.

Name	Undergraduate School	Status	Areas of Interest (including MDA)	Advisor
Jason Brewer	Georgia Tech	M.S.	propulsion, economics	Schrage
Dan DeLaurentis	Florida Tech	M.S./Ph.D.	stability & control	Calise/Schrage
Bryce Roth	Georgia Tech	M.S.	propulsion, aero, signatures	Mavris
Scott Zink	Georgia Tech	M.S.	aeroelasticity, structures	Mavris
Jason Mortzheim	RPI	M.S.	propulsion, infrastructure	Craig
Andrew Baker	Notre Dame	M.S.	rotorcraft, design	Schrage

It should be pointed out that all of these students earned a grade point average (GPA) of greater than 3.5 as an undergraduate, and Scott Zink earned a perfect 4.0 as an undergraduate at Georgia Tech. In fact, the Aerospace Systems Design Lab at Georgia Tech was more successful than any other of the discipline groups in recruiting the best of our own outstanding graduates.

## Placement of Fellows in 1995

A key component of the NASA MDA Fellowship program is the placement of Fellows in high level internships with industry partners during one quarter of each year. As noted above and described in more detail in the grant proposal, this aspect of the program is particularly important for MDA research and training. The importance of academic research is typically measured by the peer review of the resulting papers submitted to archival journals. In the same manner, the importance of MDA research must, in significant measure, be determined by the relevance to and acceptance by the aerospace industry.

Figure 2 shows the industrial relationships that have been developed by the ASDL in support of the graduate academic programs. These were under development prior to the current program but the MDA Fellowships have significantly enhanced and expanded this interaction. As can be seen in the figure, there are currently a number of companies actively involved with ASDL and there are others considering or planning to participate in the coming year.

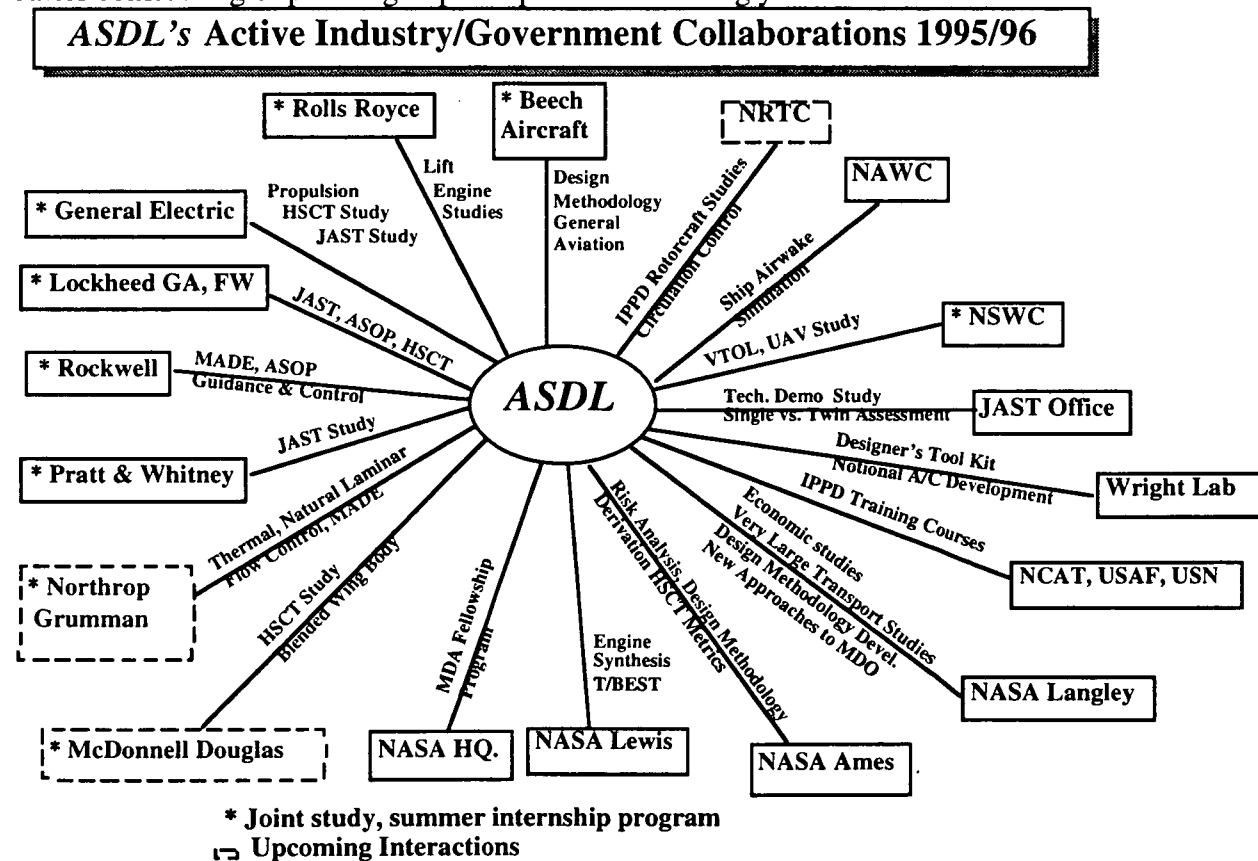


Figure 2. ASDL Industrial Interactions

During the summer of 1995, four of the NASA MDA Fellows were placed in internships in industry and these are summarized in the table below. The copies of overhead transparencies that summarize the experiences of each student are included in Appendix B.

MDA Fellow	Company	Sponsor	Topic
Jason Brewer	GE Aircraft Engines	S. Gilkey	HSCT robust engine design simulation
Dan DeLaurentis	Rockwell Int'l - NAA	R. Schwanz	Guidance optimization in aircraft MDO
Scott Zink	Lockheed -Marietta	P. Cole	HSCT takeoff optimization
Bryce Roth	GE Aircraft Engines	J. Charneski	Combustor liner impingement cooling analysis

## Academic Program Development

The baseline M.S. and Ph.D. programs of study described in the Fellowship proposal have been further developed along the lines proposed. The objective of the continuing enhancements are:

- Incorporate the latest developments in rapidly evolving MDA technology,
- Provide significant experience with synthesis in graduate design sequences in aircraft, rotorcraft and spacecraft areas,
- Develop clearly defined tracks for M.S. and Ph.D. programs in these areas.

Significant accomplishments have been made to date in all areas. Professors Dimitri Mavris and John Olds have been added to the faculty and are members of the ASDL. Professor Mavris has been associated with the ASDL as associate director and lab manager for several years and his faculty appointment confirms his importance to the program. Professor Olds, who joined the faculty in September, brings a strong interest and experience in space technologies to the ASDL, and he will assume primary responsibility for this area of activity. In addition to introducing a number of space technology courses during the next years, Prof. Olds will also be leading efforts to develop M.S. and Ph.D. tracks in this critically important area.

All existing courses in the Program have undergone continuous revision to incorporate the latest developments in MDA. In particular, Prof. Mavris is now teaching the *AE4353 Design for Life Cycle Cost* course and introducing new material on statistical-based approaches from his ongoing research in this area. Prof. Olds is currently teaching *AE6350 Design Optimization* course and is introducing a wide range of optimization technologies with applications to aircraft and spacecraft. Finally, the graduate design courses, *AE6351,2* are being reconfigured into three sections, each focusing on one of the ASDL application research areas: aircraft design, rotorcraft design and spacecraft design. As in the past, these courses will focus their study, where applicable, on the relevant national design competition. It should be pointed out that participants in these and related courses last year won First Place in the AIAA Air Breathing Propulsion Design Competition and Second Place in the AHS Rotorcraft Design Competition.

A significant effort is under way to introduce a Ph.D. Qualifying Examination area in Aerospace Systems Design and Integration. This effort is critical to the long-term viability of the Ph.D. program, and the effort to introduce this examination area has been greatly aided by the presence of the NASA MDA Fellowships and the outstanding students that it has attracted during the first year. It is anticipated that this examination area will be formally accepted for introduction during the first examination scheduled for the 1996-97 academic year. This will allow selected current MDA Fellows to choose this area (along with two other traditional disciplines) when they formally enter the doctoral program. Addition of this topic will increase the number of examination topic areas to 12, of which 3 must be selected by each candidate.

A new academic program development effort has been under discussion during the first year and will be proposed for further development and implementation in the next two years. The IPPD Certificate Program will complement current Certificate Programs in Computer Integrated

Manufacturing Systems (CIMS), Management of Technology (MOT), and Test and Evaluation (T&E). While each of these current Certificate Programs addresses certain areas of life-cycle engineering, they do not address the high-leverage, up-front design environment for large-scale, complex systems, most clearly represented by aerospace systems. The MDA Fellowship Program can serve as a catalyst for establishing the IPPD Certificate Program. Initial planning will be to include core courses team-taught by faculty from the College of Engineering, College of Computing, and the College of Management, International Affairs and Public Policy. Five core courses are envisioned:

- Introduction to IPPD/CE,
- Design for economic and life-cycle costs using quality engineering methods,
- System decomposition and synthesis using system engineering and MDO methods,
- Creation of an IPPD-oriented computing environment, and
- Decision support problem techniques for designing open engineering systems.

## Collaboration and Dissemination of Results

To date, dissemination of results has been almost entirely by traditional means. These have involved conference presentations (more than 15) and archival journal articles (6 under development for submission within the next few months). In addition, most of these documents are currently available for browsing and downloading on the ASDL Web server under the appropriate research topics (e.g., <http://www.ae.gatech.edu/research/>). In some instances, example software is also being made available to transfer the technology described in the papers. These efforts will continue and further use will be made of Web technologies.

Collaborative efforts have been focused most strongly on the university-industry interaction as outlined in the Proposal. The placement of 4 Fellows in key internships during what can only be called a "preliminary" summer program attests to the importance of this effort and to the response from industry. This will be continued during the next academic year and it will be expanded to the additional companies shown in Figure 2.

Additional collaborative efforts are under way with another NASA MDA Fellowship Grantee in the region. Efforts have been initiated to develop collaborative research and research training programs with Clemson University. Meetings at both Georgia Tech and Clemson were held during the Fall Quarter to explore these areas. Students and faculty from both programs presented summaries of plans and current activities. It has been agreed to pursue several promising areas of collaboration as described below:

- Initiate video teleconferencing to allow joint participation in "brown-bag lunch" seminars, formal MDA seminars, and in M.S. and Ph.D. proposal presentations and final defense presentations. It is expected that the first such events will take place early in 1996 using appropriate facilities at both universities. One objective of this effort will be to evaluate this technology along with desktop video teleconferencing for further collaborative work.
- Explore ways to incorporate students from both universities in national design competitions. Such competitions would be chosen for emphasis on aircraft, rotorcraft and spacecraft design and would combine the traditional strengths in aerospace engineering at Georgia Tech with the complementary strengths in traditional mechanical engineering, including rapid prototyping and industrial psychology, at Clemson.
- Collaborate in the joint research activities in the subsystem packaging and virtual/rapid prototyping areas that are proposed with Lockheed-Martin in Marietta, GA.

These efforts have been strengthened by the close association and good working relationships among the faculty at both institutions.

## **Plans for Year 2**

Plans for the Year 2 will involve basically a continuation of what has been initiated during the first year. In particular, efforts will be directed to:

- Aggressively recruit the very best students from the US for the NASA MDA Fellowships. This will involve a combination of direct mailing, Web-based publicity, and personal visits to peer institutions.
- Further develop the Industry Internships and work closely with the current internship partners to make sure that the NASA MDA Fellows are involved in leading-edge research and application of MDA technology to important industrial problems.
- Continue to pursue collaborative efforts with Clemson to share experience and to cooperate in both the teaching and research efforts.
- Enhance the existing M.S./Ph.D. program of study by the addition of new courses, the enhancement of existing courses to add the latest materials, and the introduction of a Qualifying Exam area in Aerospace Systems Design and Integration.
- Establish an Integrated Product and Process Development (IPPD) Certificate Program at Georgia Tech.

We plan to have the full complement of 10-12 Fellows in place for the start of the 1996-97 academic year, with commitments for Summer Internships for all.

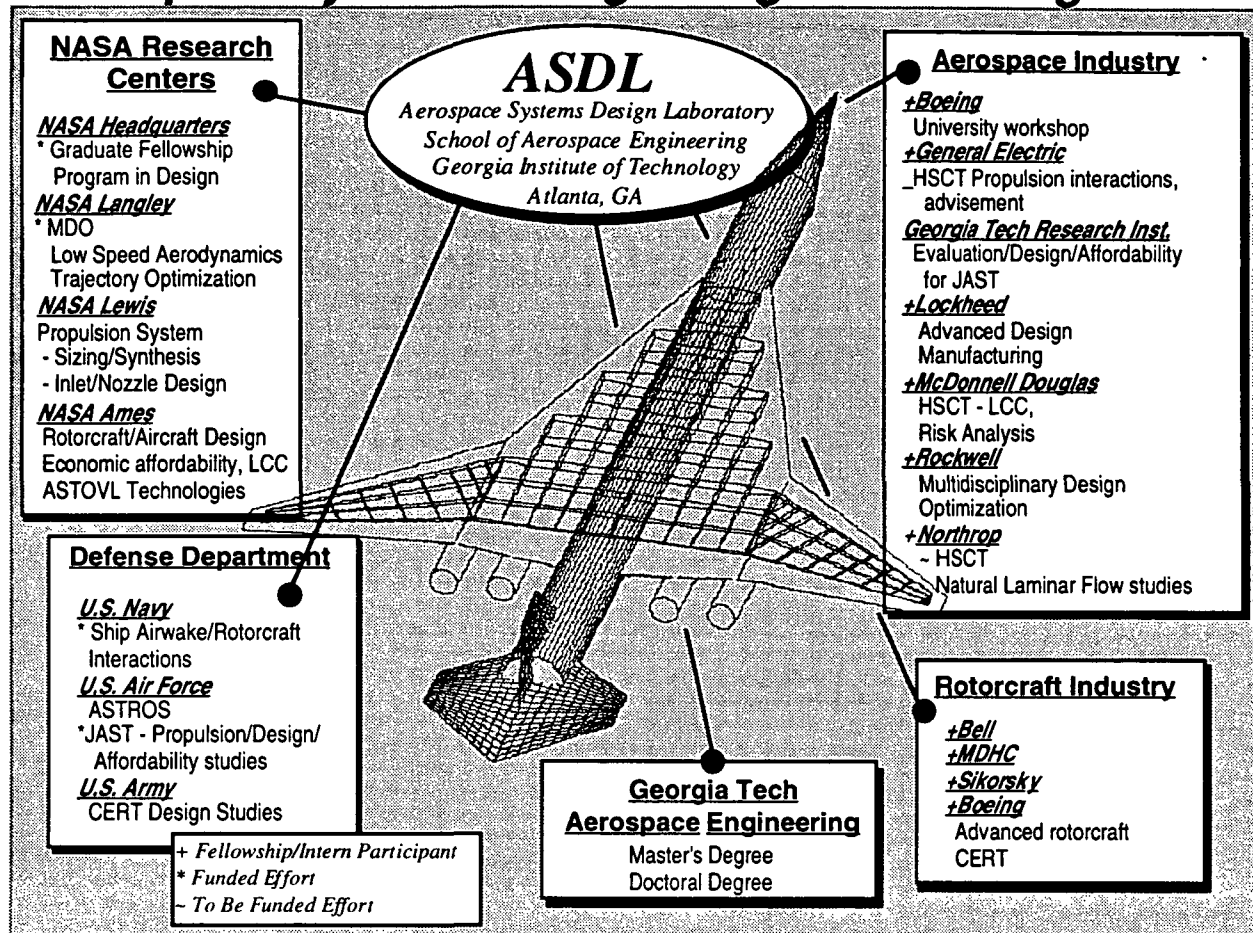


## **Appendix A**

### **NASA Fellowships in Multidisciplinary Design and Analysis at Georgia Tech**

The following material includes announcements and advertisements prepared for the NASA MDA Fellowship Program at Georgia Tech. This information has been disseminated over the past 9 months using conventional and electronic means.

# Aerospace Systems Design Program at Georgia Tech



The Georgia Tech Aerospace Systems Design Program is a graduate education and research program established in 1985 and funded in part by NASA, DoD and the aerospace industry. The Program offers a challenging curriculum that is structured to produce the next generation of leaders in aerospace design and systems integration.

Aerospace systems for the 21st century offer unmatched challenges for complex system design and systems integration that will require the very best in engineering technology and leadership. These systems will include highly efficient subsonic transports of all sizes, High Speed Civil Transports (supersonic transports), advanced design rotorcraft (helicopter, tiltrotor) as well as more cost-effective spacecraft and improved military aircraft of all types.

Continued U.S. aerospace competitiveness will require a growing pool of engineers that can develop and apply the advanced product and process design technology essential to maintain this leadership.

The Aerospace Systems Design Program provides opportunities to study, develop, and apply engineering technologies for:

- integrated product and process development (IPPD) methodologies,
- multidisciplinary design and analysis,
- robust design methods,

- multidisciplinary design optimization,
- decision-support problem structure, and
- advanced computer-integrated environments to support IPPD.

Georgia Tech was one of five universities that recently received major NASA funding to establish graduate fellowships in multidisciplinary design and analysis (MDA) for aerospace engineering. The program will support as many as ten NASA MDA Fellows who will also be Summer Interns with ten aerospace companies that have agreed to support this program. Opportunities in both the Masters and Doctoral programs are available.

NASA MDA Fellowships, research assistantships and teaching assistantships in the Aerospace Systems Design Program are available to highly qualified students with aerospace, mechanical or computer science backgrounds.

For more information contact:

Graduate Coordinator  
School of Aerospace Engineering  
Georgia Institute of Technology  
Atlanta, GA 30332-0150

Internet: [info@aerospace.gatech.edu](mailto:info@aerospace.gatech.edu)  
WWW: [www.ae.gatech.edu](http://www.ae.gatech.edu)  
Phone: (404) 894-6046

# **NASA Fellowships in Multidisciplinary Design and Analysis at Georgia Tech**

*Winter 1995*

## **Background**

Aerospace Engineering is fundamentally a multidisciplinary activity involving aerodynamics, propulsion/combustion, structures/materials, flight mechanics/controls, and manufacturing. The aerospace industry is likewise a large scale systems business which integrates into highly complex products not only the aerospace engineering disciplines, but also the disciplines of other engineering fields, such as electrical, mechanical, industrial and chemical engineering. Surprisingly, even though large scale systems integration is a core and often dominant competency for aerospace companies, aerospace engineers have not been taught or thought of as systems integrators. Systems engineering is often taught as a separate engineering field or is identified with industrial engineering.

Complex new aerospace products based on information-dominated design and manufacturing methods are already forcing the aerospace industry to deal with entirely new scales of complexity. Some products require levels of precision, delicacy, or cleanliness that human assembly can no longer directly provide. International economic competition has grown enormously in the last decade, and several U.S. aerospace companies are no longer the world leaders. Airbus Industries is now the second largest producer of commercial transport aircraft, while McDonnell Douglas Aircraft Company is now third. To regain or maintain vitality, U.S. aerospace companies are becoming leaner and are using information technologies to design and build complex systems. Both the technologies and the understanding of how best to use them have been advancing and are changing the way customers think and aerospace companies operate. As a result, from conceptualization of an aerospace system through research, development, source selection, distribution, and marketing, aerospace engineering is becoming a set of information-gathering, analysis, decision-making, dissemination, and archiving activities.

## **Georgia Tech**

Recognizing the cultural and real process change taking place in the aerospace industry and in aerospace engineering, the School of Aerospace Engineering at Georgia Tech is undertaking an evolving change in its graduate aerospace systems design program. The program, already unique among aerospace schools, is not only addressing the interdisciplinary interaction of the traditional aerospace engineering disciplines with design, but it is also addressing the integration of design and manufacturing to support the Integrated Product and Process Development (IPPD) environment being created in industry. The program has received national attention and industry and government are expressing support for our initiatives by funding a number of research projects, either solely or jointly with industrial team members.

The graduate aerospace systems design program focuses on both the M.S. and the Ph.D. programs of study, and combines the traditional classroom and laboratory instructional formats with team-based participation in national design competitions. In addition there are frequent opportunities for graduate internships with major aerospace industrial partners, and student participation in these activities is actively encouraged.

## **NASA**

The National Aeronautics and Space Administration, NASA, has recently created a unique national academic program to support graduate education in multidisciplinary design and analysis (MDA). Georgia Tech is one of only five leading U.S. universities that have been awarded multi-year programs to develop new and innovative initiatives in this area. The program supports graduate education in MDA through a

combination of academic work at Georgia Tech matched with advanced industrial experience in an industry internship and direct interaction with NASA research centers.

## **NASA MDA Fellowship Program**

The NASA MDA Fellowship Program supports Fellows who are selected from among the most highly qualified of the domestic (permanent resident) graduate applicants each year. These prestigious one-third time fellowships carry an added stipend in addition to full tuition (total award will be up to \$15k each). The applicant's academic preparation, GPA/GRE scores, industry or other practical experience, and previous research will all be considered in the selection process. Fellowships may also be awarded to students who have demonstrated two or more quarters of outstanding graduate study at Georgia Tech. The Fellowships carry the stipulation that they may be revoked on the basis of unsatisfactory academic or research performance.

The NASA MDA Fellows are normally recruited out of the M.S. Program of Study, and it is expected that they will earn the M.S. degree at the end the first year of residency. The exceptional Fellows are strongly encouraged to continue the fellowship into a doctoral program of study. A limited number of very highly qualified Fellows are recruited directly into the doctoral program. In either case the emphasis is on the M.S. Program but options may be provided for support through the doctoral program of study (subject to continued funding).

### **Program Supervision**

The NASA MDA Fellows are supervised by faculty teams (co-advisors) consisting of a design faculty member, a discipline-specific faculty member and an industry sponsor. This is a key component of the team-building strategy in the MDA Fellowship Program. It provide the critical balance between breadth across the design process and depth within recognized aerospace disciplines and industry experience. By careful selection of co-advisors, all of the major technologies that are critical to aerospace systems design are included in the Program.

### **Schedule**

A sample program schedule for the NASA MDA Fellowship Program is outlined below. The Program includes both a one-year MS program and a doctoral program. It should also be noted that the doctoral program may extend beyond the present three year funding limit of the NASA MDA Fellowship Program, and it must be emphasized that support beyond the first year award is subject to satisfactory performance and available funding.'

#### 1st year

MS: Introductory design sequence; design project; discipline concentration; *graduation*.

PhD: Design technologies theory and methodology supporting design sequence and design project.; 3 months with industry.

#### 2nd Year

MS: Repeat of 1st year for next group of students.

PhD: Design and discipline qualifying exam prerequisites; 3 months with industry.

#### 3rd Year

MS: Repeat of 1st year for next group of students.

PhD: Qualifying exam (October); dissertation proposal; co-teach class; industry visits; Time to be determined.

#### 4th Year (NASA funding not anticipated)

MS: Repeat of 1st year for next group of students.

PhD: Industry visits; finish research; dissertation; defense; *graduation*.

## **Other Program Features**

### CIMS Certificate Program

NASA MDA Fellows are encouraged to participate in related activities within the College of Engineering and outside the College. Opportunities are available for students to participate in Georgia Tech's nationally recognized graduate Computer Integrated Manufacturing Systems (CIMS) Certificate Program. This optional Program is supported by industry affiliates and ARPA funding and is organized as a multidisciplinary graduate program of study. A CIMS Certificate can be earned along with the M.S. or Ph.D. degrees with additional multidisciplinary coursework. Credit for industry experience or the aerospace systems design project can be applied towards the CIMS certificate.

### Other Projects

Fellows can also participate in other focused multidisciplinary projects. Examples include the Georgia Tech Aerial Robotics System (GTARS) education project and the Autonomous Scout Rotorcraft Testbed (ASRT) research project. The GTARS project is organized at the College level and focuses on the annual international competition to design, build and repetitively fly an autonomous air vehicle over a predefined course. The ASRT program is an Army research project with its objective the development of a testbed for the determination of emerging automation techniques using IPPD methods.

## **Application**

Interested students are encouraged to apply to the NASA MDA Graduate Fellowship Program by contacting the Graduate Coordinator in the School of Aerospace Engineering at Georgia Tech:

Graduate Coordinator School of Aerospace Engineering Georgia Institute of Technology Atlanta, GA 30332-0150  Internet: <a href="mailto:info@aerospace.gatech.edu">info@aerospace.gatech.edu</a> WWW: <a href="http://www.ae.gatech.edu">www.ae.gatech.edu</a> Phone: (404) 894-6046
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## **Appendix B**

### **Summaries of NASA MDA Fellowship Industry Internships Summer 1995**

The following copies of overhead transparencies were prepared by the NASA MDA Fellows who participated in industry internships during the summer of 1995.

# 3770 Combustor Liner Impingement Cooling Analysis

Bryce Roth  
NASA MDA Fellow  
and

Joe Charneski  
GEAE Heat Transfer

in conjunction with  
GE Aircraft Engines  
and

Georgia Tech Aerospace Systems Design Lab

**ASDL**

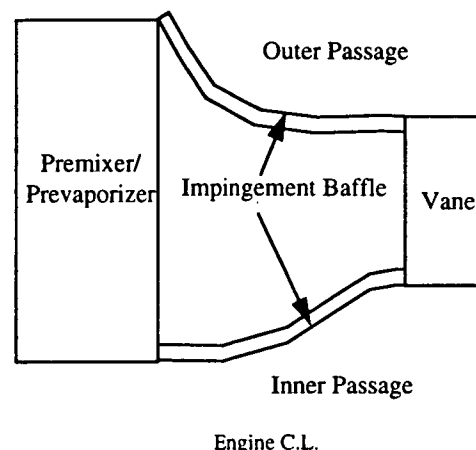
**GE Aircraft Engines**

## Background

**TASK:** To study local heat transfer in impingement cooled combustor liners and define reasonable limits for impingement geometry.

- LPP Combustor Designs Require Most of the Compressor Discharge Air to Pass Through the Dome, Leaving Little for Cooling Purposes (Approximately 1/6 That of a Typical Combustor)

- Low Coolant Flow Rates Necessitate a Highly Efficient Cooling Scheme to Get the Maximum Heat Transfer Possible With the Minimum Possible Coolant Flow Rate

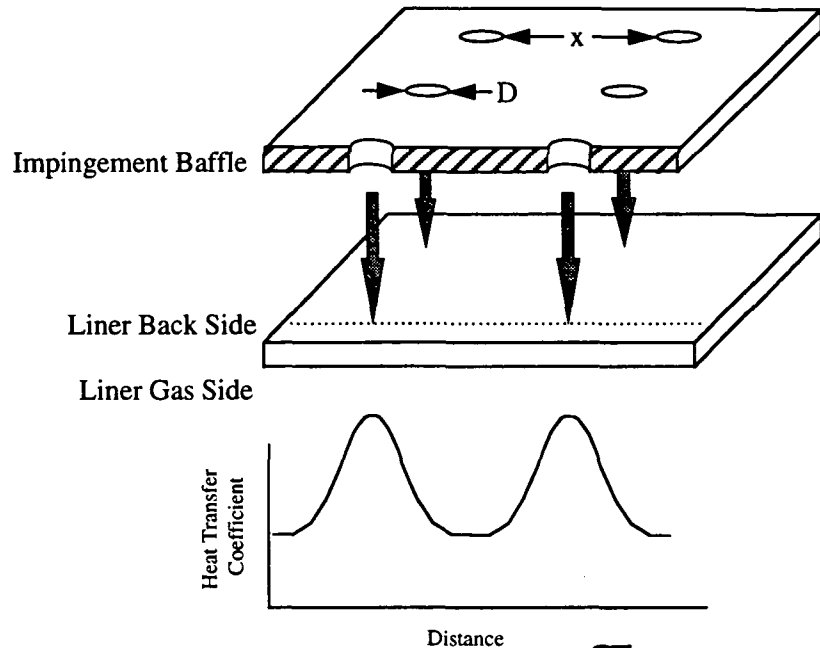


**ASDL**

**GE Aircraft Engines**

## Impingement Cooling

Impingement cooling can give very high local heat transfer at points under the impinging jet, but the heat transfer at points away from an impinging jet will have lower heat transfer, resulting in higher local temperatures. These local "hot spots" can lead to liner overtemperature and decreased liner service life.



ASDL

GE Aircraft Engines

## Benefits

- As an incoming graduate student, gained a great deal of research experience
- Interacted with highly knowledgeable engineers which provided a chance to gain from the benefits of their experience
- The challenging problem studied generated ideas for future research in the graduate program

ASDL

GE Aircraft Engines





## *NASA MDA Fellowship Program*

# **Overview of Summer Study for Daniel DeLaurentis**



**July - September 1995**

**Industry Sponsor: Rockwell International -North American Aircraft (NAA)  
Seal Beach, California**

**Mentor: Dr. Bob Schwanz, NAA Director of MDO**

**Topic: Guidance Optimization in Aircraft MDO**

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## **Impressions of Internship Experience**

### *Positives*

- Mentor was very well-versed in both disciplinary (Flight Mechanics and Controls) as well as Multidisciplinary Optimization issues
- Tasks for the summer were very well balanced in relation to desires/needs of both RI-NAA and GT-ASDL
- Interaction with individuals at Rockwell's Science Center (especially in the area of optimization) as well as NAA was a valuable asset (and a key reason why the internship was successful)

### *Negatives*

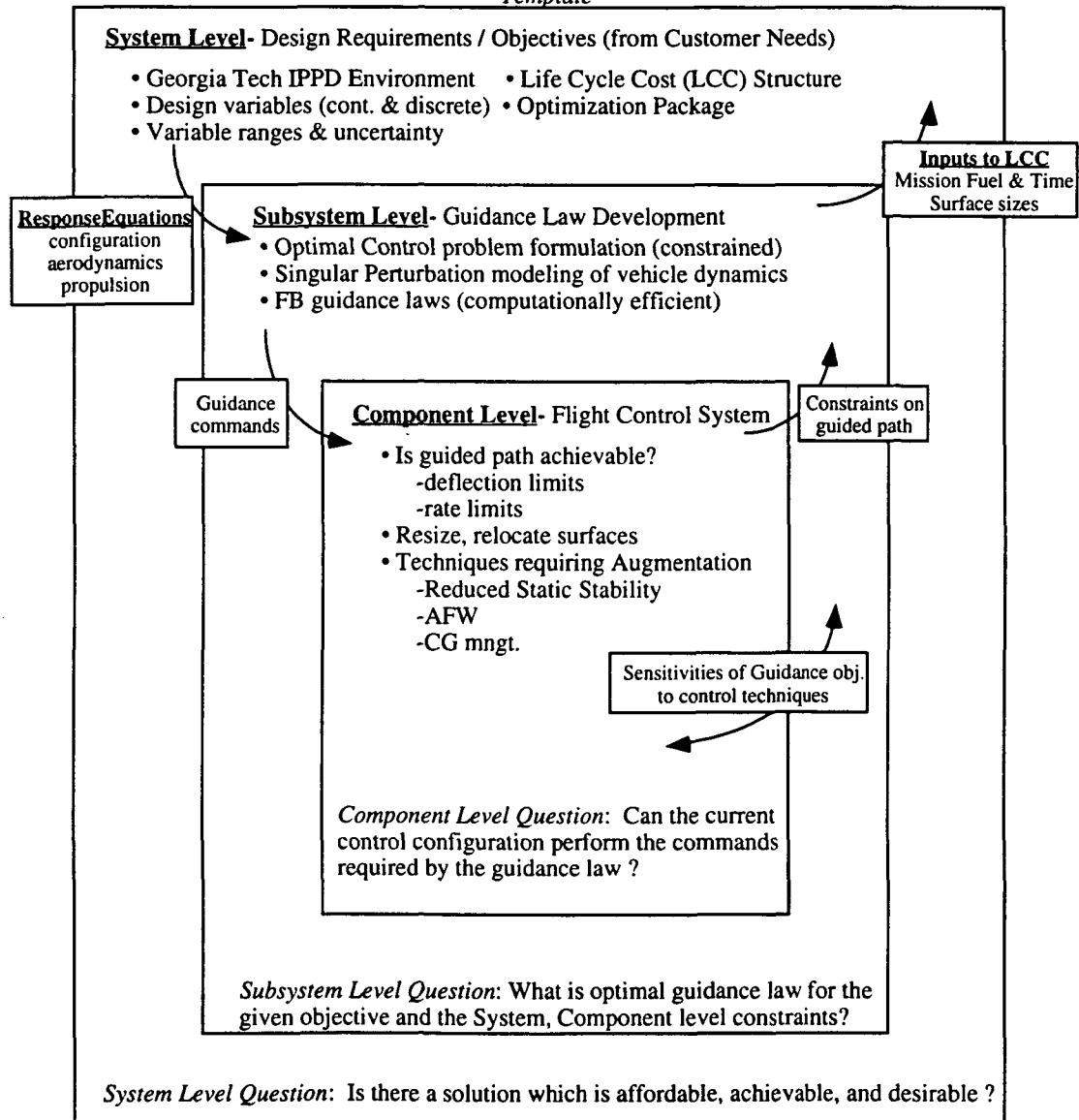
- Ongoing downsizing at NAA made for a "realistic", yet sometimes subdued work environment
-

# Multilevel G&C Analysis

## using Response Surface Equations and analytical guidance law development

### Development of a Generic Guidance & Control Decomposition/Recomposition

#### Template

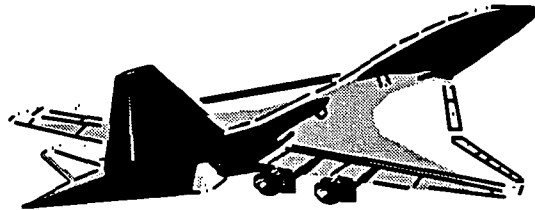


#### If successful, What are the Benefits ?

- guidance optimization more rapid, efficient than full-state numerical approaches
- procedure is amenable to conceptual and preliminary MDO problems
- potential for obtaining achievable guidance laws, not just optimal ones
- ability to assess performance gains due to advanced control techniques
- incorporation of system level objectives (e.g. LCC), which are the important payoffs

# Mach 2.0 HSCT Robust Engine Design Simulation (REDS) Study Using Response Surface Methodology

Jason Brewer  
*NASA Multidisciplinary Analysis Fellow*



General Electric Aircraft Engines  
Summer Internship

Supervisor  
Samuel Gilkey - Program Manager, HSCT

Mentor  
Philip Viars - Senior Staff Engineer, Aircraft Evaluation

*GE Aircraft Engines*

**ASDL**

## Work Plan

### Overall Objective:

Setup a Multidisciplinary Design Optimization (MDO) approach examining the design and economic robustness related to a Mixed Flow TurboFan (MFTF) installed on a Mach 2.0 HSCT Configuration.

### Individual Tasks:

- Calibrate/setup baseline Mach 2.0 HSCT configuration using FLOPS
- Learn how to use and operate computer codes (e.g., CWS, PET, and CPD) that will be used to carry out the RDS methodology.
- Identify the design variables to be explored.
- Identify the economic variables where uncertainty can be introduced.
- Determine the responses of each computer code that will be monitored and shared.
- Identify where the RSEs can be inserted into the computer codes.
- Setup the RDS methodology scheme and execute.
- Run a confirmation test with the optimum configuration using the RSEs.

**ASDL**

*GE Aircraft Engines*

## **Internship Summary of Scott Zink**

- **Lockheed-Martin Aeronautical Systems Company, Marietta, GA**
- **Department -- Advanced Design**
- **Supervisor -- Paul Cole**
- **Mentor -- Aaron Harcrow, Jr.**
- **Summer Project -- Performed task under High Speed Research IRAD to study advanced takeoff procedures that would allow sizing of an HSCT to minimum TOGW.**

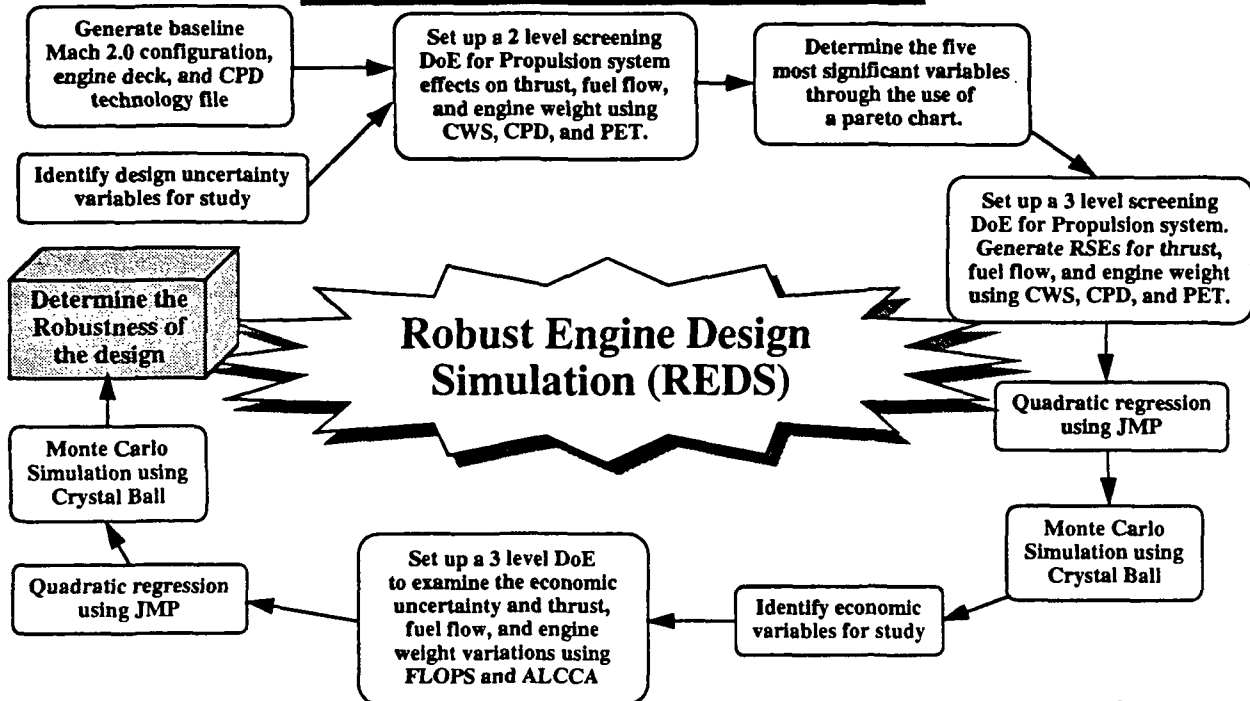
## **Summer Objectives**

- **Minimize TOGW for an HSCT**
- **Satisfy performance constraints (takeoff field length, climb time, climb gradient, etc.)**
- **Satisfy Stage III noise requirements with the aid of advanced takeoff procedures**
- **Lay the foundation for future studies of more advanced takeoff procedures, including programmed lapse rates and programmed flaps**

## **Results**

- **Used numerical optimization (reduced gradient method)**
  - Advantage**
    - **Was able to use a wide range of design variables and constraints to optimize a desired objective function (TOGW)**
- **Created stand-alone FORTRAN takeoff program**
  - Used to return takeoff parameters (field length, gradient, etc.) and noise levels as T/W and W/S were parametrically varied**
  - Used routines, when possible, extracted directly from Lockheed-Martin sizing code ASSET (Aircraft Synthesis and Sizing Evaluation Technique)**
  - Maintained compatibility with current sizing codes**
- **Linked numerical optimizer and stand-alone program to minimize TOGW numerically, instead of by traditional design plot**

## Overall Methodology



~~ASDL~~

**GE Aircraft Engines**

## Internship Pros and Cons

***Pros:***

- Developed an excellent relationship with the HSCT department at GE Aircraft Engines.
- Learned a great deal about how engines and aircraft are evaluated.
- Work nicely complemented our ASDL work on Robust Design.
- Began a study that will eventually lead to my Ph.D. thesis.

**Cons:**

- Engine and aircraft data for Mach 2.0 was not readily available at start of study.
- If the study was done for a Mach 2.4 aircraft, the study could have been completed at GE rather than having to perform much of the analysis back at Georgia Tech.
- GE personnel were slow to agree on new methods of screening variables for the study (GE had done their screening differently in the past.)
- Because the study was not able to be completed at GE, I could not run all of the computer codes myself. This was very inefficient to have GE personnel running some of the engine codes.

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## GE Aircraft Engines